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Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

99202162.6

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Der Präsident des Europäischen Patentamts:
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For the President of the European Patent Office

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Blatt 2 der Bescheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

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Demande n°:

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Titre de l'invention:
Loudspeaker protection system having frequency band selective audio power control

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Remarques:

Loudspeaker protection system having frequency band selective audio power control.

The present invention relates to a loudspeaker protection system comprising filter means for defining one or more frequency bands of an audio signal.

The present invention also relates to a audio set provided with a loudspeaker protection system.

Such a loudspeaker protection system is known from DE-AS 24 15 816 and can be applied in compact, small size, so called micro, mini or midi audio sets. The known loudspeaker protection system comprises respective bandwidth controllable filter means, whose individual bandwidths in particular in the low and high frequency bands are controllable by means of a control means coupled to the loudspeaker of the system. In order to thermally protect the loudspeaker against short or long lasting overload the filter means can be influenced by decreasing the output level of the audio signal for the loudspeaker. Merely decreasing the loudspeaker output level within e.g. a bass frequency range may provide some protection, but at the same time it is a disadvantage of the known loudspeaker protection system that it sacrifices loudspeaker output power unnecessary and thus fails to make effective use of available loudspeaker output power. In addition this sacrifice of output power is a major commercial disadvantage in particular for the young aged target group of these audio sets.

Therefore it is the aim of the present invention to provide a loudspeaker protection system, which is made effective for the specified purpose of protecting the loudspeaker only, without unnecessary effecting the full power range available for the loudspeaker.

Thereto the loudspeaker protection system according to the present invention is characterised in that the loudspeaker protection system further comprises controllable amplifier/attenuator means coupled to the filter means, and processing means coupled to control the amplifier/attenuator means, such as to determine audio power in at least one of said

in S_1 may be used to activate the amplifier/attenuator means to function as a slow term thermal protection. Similarly S_2 for example containing frequency components around the so called Helmholtz frequency (e.g. between 25 Hz and 85 Hz for a bass reflex loudspeaker system) provides accurate information about the actual excursion of the cone of the loudspeaker. So the information contained in S_2 may be used to activate the amplifier/attenuator means to function as a fast cone excursion protection.

A still further embodiment of the loudspeaker protection system according to the invention is characterised in that the processing means are capable of summing S_j over a specified subrange of possible values of j, where j is in the range from 1, 2, ... n.

Advantageously summing S_j over possibly all values from 1 to n reveals a value of S which represents information about he momentaneous electrical dissipation in the loudspeaker. So the information contained in S may be used to activate the amplifier/attenuator means to function as a fast thermal protection.

In practise some sensible and fast enough summed value or combination of values S_j will be used so that if these respective values approximate some normalised individual value S_{norm} the amplifier/attenuator means are controlled by the processing means to take proper action to protect the loudspeaker.

By in a still further embodiment of the invention determining S_j or any summation thereof every 0.001 - 2 sec., in particular every .1 - 1 sec updated data are derived such that an accurate and reliable protection is available at all times. Advantageously the present invention can be applied not only in the low frequency range for bass loudspeakers, but also for mid-tone and high-tone loudspeakers.

Principally various values and value control methods are possible for the amplifier/attenuator means but preferably in another embodiment of the loudspeaker protection system they are controlled such by the processing means that attenuation factors of the amplifier/attenuator means are proportional to:

$$1 / \sqrt{\alpha} + \beta_j (1 - 1 / \sqrt{\alpha})$$

where $\alpha = S / S_{norm}$, and β_j represents a factor whose value depends empirically on the particular frequency band j.

v1-vn. The processing means 4 provide control signals Vc1-Vc(n-1) to the correspondingly designated control inputs of the amplifier/attenuator means. Additionally in a further embodiment of the loudspeaker protection system 1 further control information may be derived from a measuring element, such as a resistor Rm, which through a further bandpass filter BPMm, an amplifier Am and a further peak detector Pm, which control information is also conveyed to the processing means 4. Principally all constituting elements of the loudspeaker protection system 1 can be implemented in either an analog, or digital, or hybrid way, whereby conversion takes place by means of suitable A/D and D/A convertors and, where possible, multiplexers are applied to reduce the number of necessary convertors. The processing means 4 can be implemented by means of a properly programmed processor, such as a microprocessor or computer.

The functioning of the loudspeaker protection system 1 is as follows. The audio signal on input terminal 2 is divided in separate frequency bands by the filter means BPF1-BPFn. The audio power S_j in each of the frequency bands j is being calculated repeatedly by the processing means 4 in the embodiment as shown as:

$$S_j = v_{jtop}^2 * R\{Y_j\} * (A_3)^2,$$

where v_{jtop} is the peak value of the amplitude of the frequency components in frequency band j, $R\{Y_j\}$ is the real part of the electric admittance of the loudspeaker in frequency band j and A_3 is the gain of amplifier A3. The latter may come from a table with premeasured data concerning the electric admittance of the loudspeaker LS concerned or may be actually measured by means of the measuring element Rm, which will be elucidated later. The number n of frequency bands may for example be between 2 and 8. The lowest frequency band contains information in the form of the audio power S_1 present therein, which is a good estimate for the resistance of the voice coil of the loudspeaker. This resistance increases with the actual temperature of the voice coil. If in an audio signal at a certain moment S_1 exceeds a normalised loudspeaker value S_{norm} then the amplifier/attenuator means are activated by the processing means 4 and the control signal Vc1 is influenced to decrease the power S_1, which reduces critical audio power to the loudspeaker, such that a long term (slow) thermal protection thereof is achieved. The output power S_1 is controllably reduced as far as necessary for protection of the loudspeaker LS, whose full power range can thus safely be used.

Similarly S_2 for example containing frequency components around the so called Helmholtz frequency and above (e.g. between 25 Hz and 85 Hz for a bass reflex loudspeaker

where $\alpha = S / S_{norm}$, S_{norm} represents the further normalised predetermined value of S, and β_j represents a factor whose value depends empirically on the particular frequency band j. For example β_j may be chosen 0, 1/4, 2/4, 3/4, 1. Herein S may be summed over one or more frequency bands. For example attenuation (or inverse amplification) in the amplifier/attenuator means can even more gradually be adjusted proportional to:

$$\{\tau^x + \beta_j(1 - \tau^x)\}\{1 / \sqrt{\alpha} + \beta_j (1 - 1 / \sqrt{\alpha})\}$$

where for fast thermal protection τ exceeds 1 and x is a constant to be determined empirically. Generally it is preferred for human perception reasons that the processing means 4 are arranged to initiate control in a shorter amount of time than that the control is withdrawn.

In the above mentioned further embodiment the loudspeaker protection system 1 comprises the measuring element Rm. The data concerning the momentaneous impedance and voltage across the element Rm on for example common connection point P can be used by the processing means 4, instead of corresponding data in a memory table of the processing means 4 to have actual and thus more accurate and reliable values available for each possible combination of the above mentioned protection methods.

CLAIMS:

1. Loudspeaker protection system comprising filter means for defining one or more frequency bands of an audio signal, characterised in that the loudspeaker protection system further comprises controllable amplifier/attenuator means coupled to the filter means, and processing means coupled to control the amplifier/attenuator means, such as to determine audio power in at least one of said frequency bands representing relevant loudspeaker protection information used for selective audio power control in said at least one frequency band.

2. Loudspeaker protection system according to claim 1, characterised in that the processing means are equipped to determine the audio power S_j in frequency band j in proportion to:

$$v_{jtop}^2 * R\{Y_j\},$$

where v_{jtop} is the peak value of the amplitude of the frequency components in frequency band j, and $R\{Y_j\}$ is the real part of the electric admittance of the loudspeaker in frequency band j.

3. Loudspeaker protection system according to claim 2, characterised in that in the loudspeaker protection system j = 1, 2, 3 ... n, where n equals the number of frequency bands wherein the frequency spectrum of the audio signal is divided.

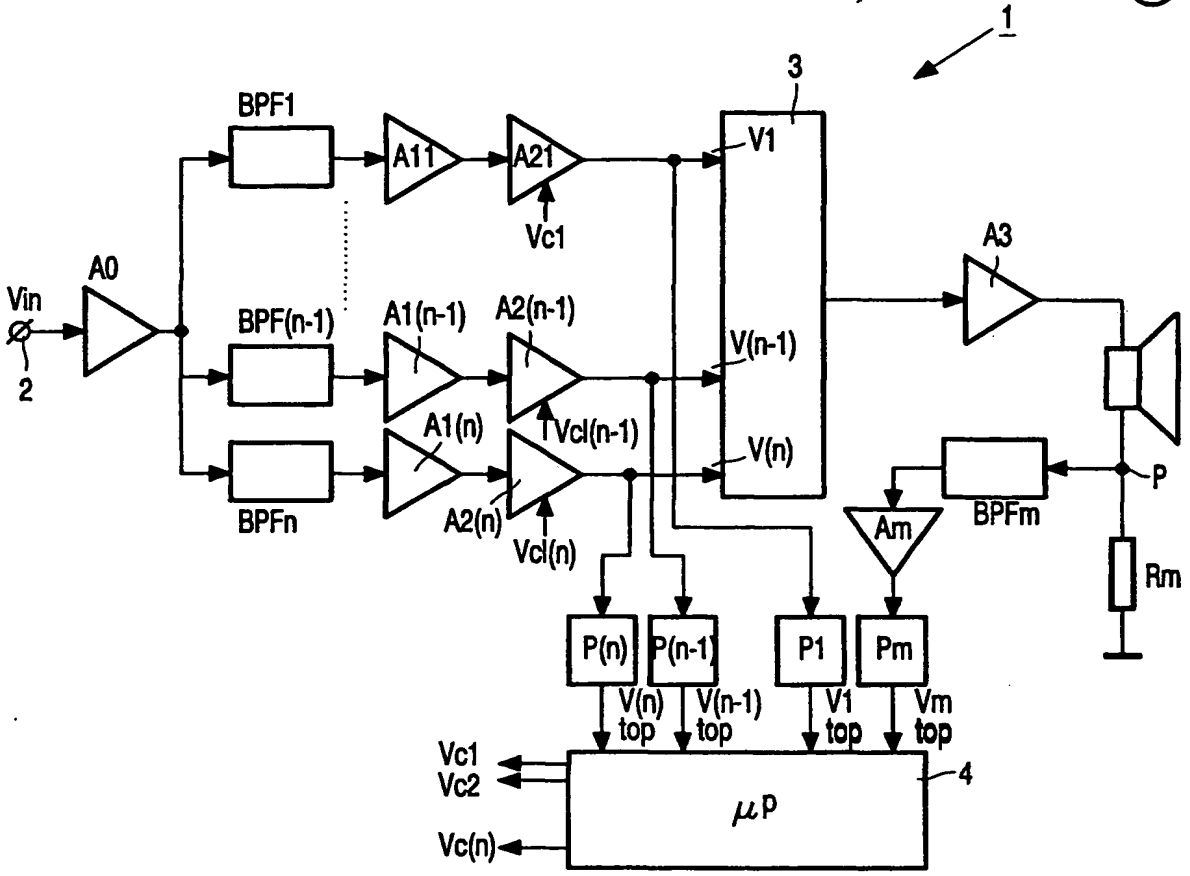
4. Loudspeaker protection system according to claim 2 or 3, characterised in that the processing means are capable of summing S_j over a specified subrange of possible values of j, where j is in the range from 1, 2, ... n.

5. Loudspeaker protection system according to claim 4, characterised in that if any summed value or combination of values S_j approximates some normalised value S_{norm} the amplifier/attenuator means are controlled by the processing means.

ABSTRACT:

A loudspeaker protection system comprises filter means for defining one or more frequency bands of an audio signal, controllable amplifier/attenuator means coupled to the filter means, and processing means coupled to control the amplifier/attenuator means, such as to determine audio power in at least one of said frequency bands representing relevant loudspeaker protection information used for selective audio power control in said at least one frequency band. This system has the features for a fast and/or slow thermal protection, as well as for a cone excursion protection all for a loudspeaker in such a system.

Fig. 1


1
3
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Vc1
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2
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V(n-1)
A3
A1(n)
Vcl(n-1)
V(n)
P
BPFn
A2(n)
Vcl(n)
Am
BPFm
Rm
P(n)
P(n-1)
P1
Pm
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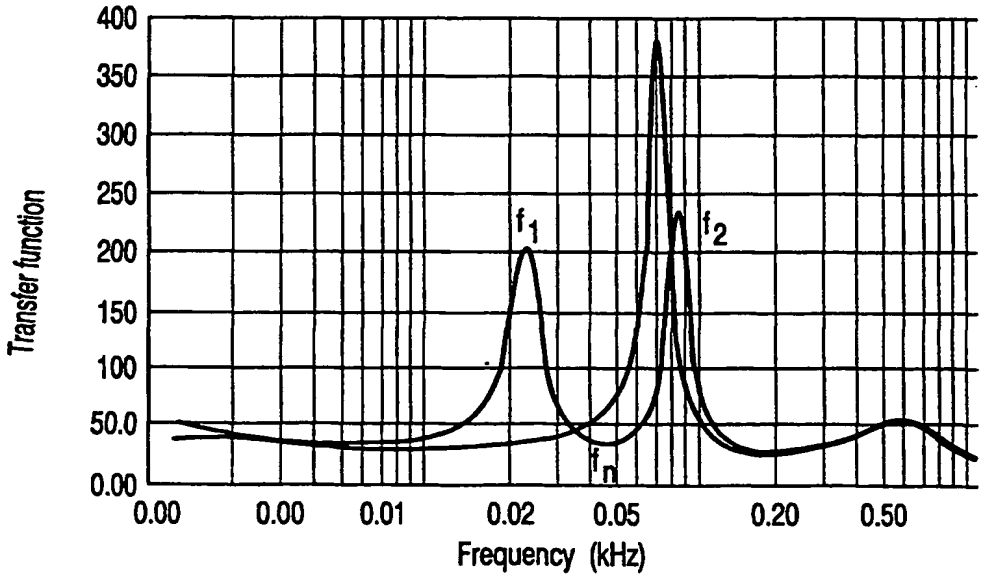
V(n-1) top
V1 top
Vm top
Vc1
Vc2
Vc(n)
μp
4

FIG. 1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200
150
100
50.0
0.00
f1
f2
fn
0.00
0.00
0.01
0.02
0.05
0.20
0.50
Frequency (kHz)

FIG. 2

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